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# IDENTIFICATION AND CHANGE DETECTION OF SPATIAL COVERAGE OF LULC, USING GEOSPATIAL TECHNOLOGY: A CASE STUDY OF AUSGRAM BLOCK, BURDWAN DISTRICT, WEST BENGAL, INDIA

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## ABSTRACT

Land use refers to, "man's activities on land which are directly related to the land" (Clawson and Stewart, 1965). Land cover refers to the bio-physical cover over the Earth's surface which includes water bodies, vegetation, bare soil, and artificial structures. Land use encompasses social and economic purposes to manage or alter land for agriculture, forestry and building construction including biogeochemistry, hydrology and biodiversity. Land use land cover (LULC) may be observed directly in the field or by remote sensing. Ausgram block is located in the east-central part of Burdwan distract of West Bengal. The district in general and the blocks in particular, have under gone several land use changes in the past century. The changing land use land cover scenarios of Ausgram Block were assessed using Remote Sensing and GIS techniques. The historic land use map has been prepared from of Survey of India topographic maps (1972). The land use and land cover maps of 2002 and 2008 were generated through the digital land use land cover classification of Land Sat 5 and 7 satellite imageries supported by ground truths. The results for three time periods revealed that agriculture is main land use land cover in this block. From 49 per cent land use land cover, agriculture increased marginally to 50.00 per cent in 2008. But forest and surface water bodies experienced decrease in the surface area coverage. As the forest and surface water bodies are two important ecologically sensitive land use land cover, specific care is necessary to prevent the decreasing trend of such resources to maintain the sustainability.

**KEYWORDS:** Spatial Coverage, Land Use Land Cover, Remote Sensing, GIS, Ground Truths

## INTRODUCTION

Land cover is defined as "the bio-physical state of the earth's surface and immediate subsurface" (Turner et al., 1995). It "describes the physical state of the land surface: as in cropland, mountains or forest" (Meyer and Turner, 1994) and is related to visual features.

Land use is strongly human related and it denotes "the human employment of land" (Meyer and Turner, 1994) and implies the way in which, and the purpose for which, human beings employ the land and its resources (Meyer, 1995). In this respect it is not related to visible features but to intention or purpose.

A modern nation, as a modern business, must have adequate information on many complex interrelated aspects of its activities in order to make decisions. Land use is only one of such aspects, but knowledge about different categories of land use land cover has become increasingly important as the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands and loss of fish and wildlife habitat. Classified land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at

current levels. In this dynamic situation, accurate, meaningful, current data on land use are essential to make sound plans for their own future action, and then reliable information is critical.

Land use land cover change (LULCC) or change detection of spatial coverage, also known as land change is a general term for the human modification of earth's terrestrial surface. Though human have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of LULCC are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales. These changes encompass the greatest environmental concerns of human population today, including climate change, biodiversity loss and the pollution of water, soil and air. Monitoring and mediating the negative consequences of LULC while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world.

Land degradation results mainly due to population pressure which leads to intense land use without proper management practices. Over population makes people move towards sensitive areas like highlands. In such areas land use without considering the slope and erodibility leads to severe erosion and related problems. The influence of road construction and other comparable disturbances of landscape on erosion and on landslides, and other mass movements on hilly area are well known (Prakasam, 2010).

Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Kachhwaha, 1985) in association with Geographical Information System (GIS) that provide suitable platform for data analysis, update and retrieval (Star et al. 1997; Chilar 2000). Space-borne remotely sensed data may be particularly useful in developing countries where recent and reliable spatial information is lacking. Remote sensing technology and geographic information system (GIS) provide efficient methods for analysis of land use issues and tools for land use planning and modeling. By understanding the driving forces of land use development in the past, managing the current situation with modern GIS tools, and modeling the future, one is able to develop the plans for multiple uses of natural resources and nature conservation. The change in any form of land use is largely related either with the external forces and the pressure built-up within the system (Bisht and Kothyari, 2001).

Present study have been classified three time periods data to derive the LULC of the region and its spatial change over time. Information's have been derived from Survey of India topographical map (1972), Landsat imageries of 2002 September and 2008 April. The LULC of past 36 years have been studies and how the change detection of spatial coverage changes happened what are the factors behind that are investigated.

The change detection of spatial coverage of the present study area, Ausgram block has been studied. The important identified the coverage of spatial land surface are forest, agricultural land, current fallow, built-up, water bodies and barren land of fallow land. It has been observed that the land use land covers are changing through time and space. The changes are both qualitative and quantitative. The following section will evaluate such changes.

## OBJECTIVE

To identified and analysed the spatial LULC change detection of Ausgram block past 36 years through geospatial technology.

## STUDY AREA

The study area, Ausgram block is located in the central part of Budrwan District. The block is surrounded by Birbhum District in the north, Manglkote and Bhatar Blocks, Galsi Block and Kanksa Blocks of Burdwan district in the

west, south and east (Figure 1). Its geographical area is distributed between $23^0$ 21'47" N to $23^0$ 37' 04" N latitude and $87^0$ 28' 57" E to $87^0$ 47' 07" E longitude, covering 493 sq.km of area. Total population of the Block is 2, 43,113 (Census of India, 2001). Agriculture is main economic activity of the region. The altitude varies between 40m to 60m above MSL. Slope gradually decreases from south west to north east. Its maximum area is covered with clay with caliche concretion, laterite and clay alternating with silts and sand is another extensive soil cover of the region. The blocks experience a climate which is transitional between CWg3 and AW1 types, where 'C' stands for 'warm temperate rainy climates with mild winter', 'W' for 'dry winter not compensated for by total rain in the rest of the year', 'g3' for 'eastern Ganges type of temperature trend' and 'AW1' for 'tropical savanna climates' (http://bardhaman.nic.in/home.htm). Lots of surface water bodies like river, stream, nadi, canals, ponds, tanks, lakes are present over the study area. About 1670 numbers of surface water bodies are present here. The important rivers are Ajoy, Kunur and Khari. The important canals are Durgapur Branch Canal, Damodar Branch Canal, Panagarh Branch Canal.

## DATA BASE AND METHODOLOGY

This historical change of spatial coverage map has been prepared from 1:50000 scale, Survey of India topographical sheet (1972), through visual interpretation method and digital classification method (supervised classification) have been adopted and prepared the spatial coverage map of 2002 and 2008 by using satellite data sets of Land Sat 5 (Thematic Mapper), Land Sat 7 (Enhancement Thematic Mapper +).

The classified maps were interpreted and verified based on the field knowledge is employed to perform the classification. The acquired data sets have been compared, analysed and interpreted accordingly (Table 1). GIS and Remote Sensing are powerful tools for extracting the spatial coverage LULC layer, from Survey of India topographical maps and satellite imageries. The land use land cover classes include agriculture land, current fallow, forest, built-up (settlement, road, railway), Barren land, and water bodies (pond, river, canal, stream). This classification is performed based on the classification scheme of National Remote Sensing Centre (NRSC), Department of Space, Govt of India.

### Spatial Coverage of Land Use Land Cover 1972, 2002 (September) and 2008 (April)

### Agricultural Land

Agricultural land may be defined as land used primarily for production of food and fibre. Agricultural lands are croplands, orchards, groves, vineyards, nurseries and ornamental horticultural areas. India is dominated by agricultural activities and the main land use of the country is agricultural land use. According to the Census of India, the agricultural land use is divided into two categories- the irrigated land and un-irrigated land. With increasing population of the country, the demand and requirement for food is also increasing. As a result, more lands are being converted to agricultural lands. The development of the irrigation system by controlling structures, dams / reservoirs have also contributed to the rise in the area of agricultural land. Irrigated area is assumed to be irrigated for cultivation through such sources as canals (Government & Private), tanks, tube-wells, other wells and other sources. It is divided into net irrigated and gross irrigated area. Net irrigated area refers to the area irrigated through any source once in a year for a particular crop. Total/Gross irrigated area is the total area of crops, irrigated once and/or more than once in a year. It is counted as many times as the number of times the areas are cropped and irrigated in a year.

In the present study area, as like rest of the area of our country, agriculture is the main economic activity. Rice is the most important crop of the blocks and in this part of the world little else is grown. The rice grown with its numerous varieties can broadly be grouped under the three primary classes- the *Aus* or autumn rice, the *Aman* or winter rice and the *Boro* or the summer rice. In the year of 1972 paddy covered maximum of the gross cropped area and it covered 49 % of the

total study area. The area was distributed in east, south, southeast central, central parts of the study area (Figure 2 & Table 2).

Satellite data of 2002 September, Enhanced Thematic Mapper plus (ETM+), of Land sat has been analysed to study of land use land cover of the region. The classified data has been compared with 1972 land use land cover data. Paddy covered maximum area of the cropped land in 2002 also. Some land also had some vegetables. This agricultural land use covered around 60 % of total land of the block. Agricultural land was distributed in southeast, east, central, northeast parts of the region. Along with Kunur *Nadi* flourishing agricultural land with standing crops were identified and mapped (Figure 3 & Table 2).

Satellite data of 2008 (April), Thematic Mapper image has been used to study the spatial coverage of the region. As like the earlier two period's data, this data also recorded maximum area under the agricultural land. Paddy is the main verity of crop. Few per cent of land have shown vegetables cultivation. It covered around 51% of land. The agricultural land was distributed in southeast, east, central, northeast parts of the block (Figure 4 & Table 2).

**Current Fallow or Pasture**

According to Census of India, Current Fallow represents cropped area, which is kept fallow during the current year/season. For example, if any seeding area is not cropped against the same year it may be treated as current fallow. Important components of current fallow land includes harvested cropland, summer fallow, land on which crop failure occurs, cropland used only for pasture in rotation with crops and pasture land. From imagery alone, it is generally not possible to make a distinction between 'Cropland' and 'Pasture' with a high degree of accuracy and uniformity (Hardy *et. al.,* 1971).

Current fallow land covered 17 % of the total study area in the year of 1972 and it was distributed in north, northwest, northeast and southeast parts of the study area. In 2002 September, it was distributed along with natural forest covered land. The current fallow land was distributed in southwest, southwest central and west central parts of study area (Figure 2 & Table 2). The current fallow land in the year 2002 was very negligible to the total area of blocks only around one per cent of total study area. This is because of the availability of monsoon rain water. The water resource helped to use maximum possible land into agricultural land use.

The pre-monsoon season satellite image of 2008 (April) showed increased amount of current fallow land. About 11% of total study area was under this category of land use land cover (Figure 3 & Table 2). The limitation of water resources restricted the growth of agricultural land resulted increased amount of current fallow land.

Current fallow land or cultivable waste land covered 17% of total surface area of the block in 1972. In 2002 September, during the monsoon season, the fallow land decreased to one percent area of the blocks (Figure 4 & Table 2). It has increased in spatial extent in the summer or pre-monsoon months due to water stressed problem. If the water resources are properly be managed and used in the drier month, vast areas can be converted into good agricultural land use.

**Forest**

Forest lands have a tree-crown areal density (crown closure percentage) of 10 % or more, are stocked with trees capable of producing timber or other wood products and exert an influence on the climate or water regime.

Lands from which trees have been removed to less than 10 percent crown closure but which have not been developed for other uses are included in the forest category also. For example, lands on where there are rotation cycles of clear-cutting and block planting are part of forest land. On such lands, when trees reach marketable size, there may be large

areas that have little or no visible forest growth. The pattern can sometimes be identified by the presence of cutting operations in the midst of a large expanse of forest. Unless there is evidence of other use, such areas of little or no forest growth should be included in the forest land category.

Forest is very important and environmentally significant land use land cover of the study area. A significant amount of the land is under the forestland of the blocks distributed in the west, southwest and south west central parts of the study area. It covered 19 % of the total study area in 1972. Important verity of forest is *Sal* trees. From the topographical sheets, few villages are identified inside the forest. The field visits revealed that those villagers are directly dependent on the forest for their livelihood. They collect forest leaves (Sal leaves), honey and other products and sustain their livelihood.

Throughout the history there has been conflict between environment and development. Forest cover has remained very soft and easy target for the development and extension of agriculture land or industrialization or for urbanization. The Ausgram block is in no exception and showing depleting forest covers. This forest covered land at year of 2002 (September) reduced to 17% of total study area compared to 1972. This has further been reduced to 14% in 2008.

Fortunately, very recently it is observed that some villages have new man made forest (eucalyptus). The forests are distributed at the western and southern part of the study area. Some of the important forests are located at Premeani, Ruldiha, Lakshminarayanpur, Radhballavpur, Dariapur, Lakshmiganj and Alutia. The decrease of the ecologically sensitive resources may be due to conversion for agricultural lands, settlements and new roads. The decrease in the forest cover from 19% to 17 % took 30 years. But it is unfortunate to observe that from 17% (2002) it reduced to 14% (2008) within six years (Figure 2, 3 and 4 & Table 2). Feel it is very much alarming and immediate checks are to be made from government initiative.

**Built-up / Settlement and Communication**

Built-up land is comprised of areas of the land covered by structures. Cities, towns, villages, strip developments along highways, transportation, power and communication facilities and areas such as those occupied by mills, shopping centres, industrial, commercial complexes and institutions are included in this category. As development progresses, land having less intensive or nonconforming use may be located in the midst of urban or built-up areas will generally be included in this category. Agricultural land, forest, wetland or water bodies on the fringe of urban or built-up areas will not be included except where they are surrounded and dominated by urban development. The urban or built-up category takes precedence over others when the criteria for more than one category are met. For example, residential areas that have sufficient tree cover to meet forest land criteria will be placed in the residential category. Residential land uses range from high density, represented by the multiple unit structures of urban cores, to low density, where houses are on lots of more than an acre, on the periphery of urban expansion.

Areas of sparse residential land use, such as farmsteads will be included in this category. Rural residential and recreational subdivisions are also included in this category. Residential sections which are integral parts of other uses may be difficult to identify. Housing situations such as those existing on military bases, at colleges and universities, living quarters for labourers near a work base, or lodging for employees of agricultural field operations or resorts thus would be placed within the Industrial, Agricultural, or Commercial and Services categories.

According to Indian land use lands cover classification system built-up land includes all lands occupied by buildings, roads, railways, all residential, commercial and industrial development.

For the present study the 'Built-up' land includes settlements, mud roads, metal roads, railway lines, footpaths, religious places and parks. Settlements generally distributed all over the study area but most of the major settlements are located in Dig Nagar, Dwariapur, Bhedia, Amrargar, Ausgram, Eral, Belgram, Sar, Bhota, Bagram, Bhuyera, Karatia, Pubar, Brahman Dihi, Ukta and Bataaram villages. Almost all 149 villages connected by mud roads, metal roads, railway lines and by footpaths. In 1972, the transport system was not developed that much. Very few metalled roads were there and maximum villages were connected by mud roads and foot paths. Religious places were distributed in almost all villages. Railway lines crossed the study area through the north and eastern parts (Eastern Railway, *Sahibganj Loop* line) of the study area. In 1972, built-up land covered about 8% of the total land of the study area.

In 2002, the built-up land coverage increased its total covered area to 15% of the total land of Ausgram block. The increased area under settlement and communication land increased in response to the decreasing amount of land coverage from agricultural land and forest coverage. Further in 2008, the built-up land coverage has increased from 15% to 19%. Rapid growth of human population and settlement attributed the increased growth in settlement coverage. The communication lines have also increased in total length and so the density of road in the blocks has increased (Figure: 2, 3, 4 & Table: 2).

**Water Bodies**

Water body means an area that, during a year with normal patterns of precipitation, has standing water for sufficient duration to establish an ordinary high water mark and a depth of more than two meters. Water on the surface of the earth is an open body of water, such as a river, stream or lake. All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells or other collectors which are directly influenced by surface water.

Surface water means perennial and seasonal streams, lakes, ponds, and tidal waters, marshes, water courses and other bodies of water, natural or artificial. The water in most rivers and lakes is called freshwater because it is low in salts. This makes it drinkable by people although it is often not safe to drink because of chemical or biological contamination. Seawater, which is rich in salts, is not readily drinkable.

"Wetland" means an open body of water; an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support and that under normal circumstances will support a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation. Wetlands generally include swamps, marshes, bogs and similar areas.

There are different kinds of surface water bodies in Ausgram Block. They are rivers, nadis, streams, ponds, lakes, canals, tanks etc. Ajay River is flowing and forming northern boundary of the blocks. Kunur Nadi is flowing through the central part of the blocks. Kanakhori Nadi and Kandor Nadi are flowing through southwest and Kandar Nadi is flowing through southeast parts of the study area. In the year 1972, surface water bodies covered 7% of the total land of study area. It gradually decreased to 5% in 2008. From 1972 to 2008 water bodies are reduced by 2% of total land cover (Figure 2, 3, 4 & Table 2). Human activates are mainly responsible for converting the water bodies into agriculture and built-up land use.

**Lakes**

Lakes are moderate to large bodies of water. Ponds are usually considered to be small, shallow bodies of water, typically with an area of less than one acre (0.4 ha), in which sunlight penetrates to the bottom across the entire area. Lakes are larger and deeper and sunlight may not penetrate all the way to the lake bottom. Ponds respond to environmental

changes particularly sunlight, temperature and wind this in turn has an influence on the animals and plants that live there. Lakes covered 192.6 hectares of land on the study area.

**Rivers and Streams**

Stream means an open, relatively natural channel that collects and drains flows within a watershed. A stream can be perennial, intermittent or ephemeral and is defined generally by the bank full width of the channel. Streams do not include man-made channels constructed solely for the purpose of delivering adjudicated water rights or trans-basin diversions or for collecting and conveying storm water from properties into the municipal storm water collection system.

Rivers and streams form a network of channels that drain water from a large area of land called the drainage basin. Within a drainage basin, the river network usually looks like the branches of a tree, with many smaller channels, called tributaries, draining into a final main river.

In the present study, considered water bodies where the surface water or rain water stores or moves continuously more than three month per year. Major rivers and streams length in present study is 263.68 km (Table 3).

**Canal**

Canals are constructed by man to divert water. There are many canals flowing through the block, Durgapur Branch Canal, Panagarh Branch Canal, Damodar Branch Canal are flowing through the block. They are flowing mainly from the west to central parts of the block. Some of canals provide crucial water needed for irrigation. Those areas of the blocks having canal irrigation are being cultivated three times in a year. Total length of the canals in the study region is 117.84 km (Table 3).

Tanks, lakes and small streams are also distributed all over the study area. These water bodies are very important source of water for Ausgram Block for agricultural as well as for domestic purposes.

In the year 1972, 7% of the total land of the blocks was under the surface water bodies. In 2002, it reduced to about 5% of the land in Ausgram Block. From satellite imageries and through field verification it has been noticed that some ponds are being converted to agricultural lands and even to settlements. Fortunately there was no further reduction of the water bodies and it remained to about 5% to total land in 2008 also (Table 2).

**Barren Land**

Barren Land is the land of limited ability to support life and over which less than one-third of the area has vegetation or other cover. In general, it is an area of thin soil, sand or rocks. Vegetation, if present, is more widely spaced and scrubby than that in the shrub and bush category of rangeland. Unusual conditions, such as a heavy rainfall, occasionally result in growth of a short-lived, more luxuriant plant cover. Wet, non-vegetated barren lands are included in the non-forested wetland category.

Land may appear barren because of man's activities. When it may reasonably be inferred from the data source that the land will be returned to its former use, it is not included in the barren category but classified on the basis of its site and situation. Agricultural land, for example, may be temporarily without vegetative cover because of cropping season or tillage practices. Similarly, industrial land may have waste and tailing dumps and areas of intensively managed forest land may have clear-cut block evident. When neither the former nor the future use can be discerned and the area is obviously in a state of land use transition, it is considered to be barren Land.

According to the Indian land use land cover classification system, the barren land includes all barren and un-cultivable land like mountains, deserts, etc. Land which cannot be brought under cultivation except at an exorbitant cost should be classed as un-cultivable. Barren or sparsely vegetated areas most often representatives of bare earth or soil. These lands are the rock exposures and devoid of soil cover and vegetation and not suitable for cultivation. It is mainly marked on the granite exposures which are outside the notified forest boundary.

In the present study area few barren lands are available. Ajay River has deposited sands over some places in northern part, along with railway lines. In 1972, it covered 0.13 per cent of land to total study area. It covered 0.27 per cent of total study area land in 2002 and 0.20 per cent in 2008 (Figure 2, 3, 4 & Table 2).

Land use land cover of Ausgram block has changes over the past 36 years. Several ways of modification are there. Forest cover shows a gradual reduction. The reduced forest cover has mainly been added to agricultural, built-up and current fallow land. Agricultural land also shows changes due to pre-monsoon, monsoon time and some agricultural lands are converted to built-up, man made forest and current fallow land. Specifically agricultural land has been converted to current fallow land mainly due to water stressed problem. Current fallow land converted to built-up, man-made forest and to agricultural land. Surface water bodies converted to agricultural land, current fallow and built-up land due to population growth (Figure 5 & Table 2).

## CONCLUSIONS

Ausgram Block is very important agriculture regions of Burdwan District, West Bengal. The spatial change over the past three decades (36 years), have been analyzed by using two different time periods satellite data and topographical maps. The analysis revealed that the surface water bodies and forest cover is decreasing. Immediate control on the deforestation and depletion of these environmentally sensitive resources is needed. The rapid human population growth has had a great relevance to the agricultural production. But the study area has the problem of water resources and the agricultural areas are losing its land to the fallow land and built up lands. Immediate steps are needed to be taken to restore the water and forest resources and agricultural lands also. Otherwise the region may face issues like food securities, famines and droughts.

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## APPENDICES

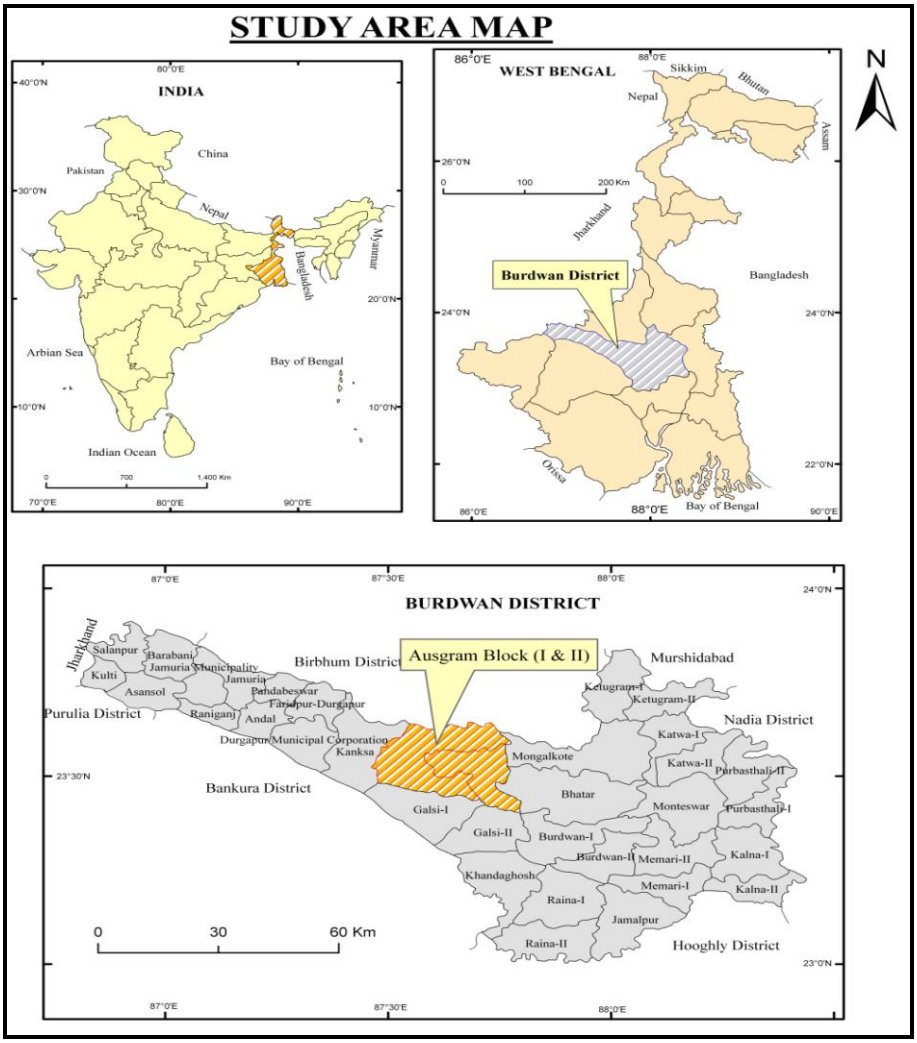


**Figure 1: Location of Study Area**

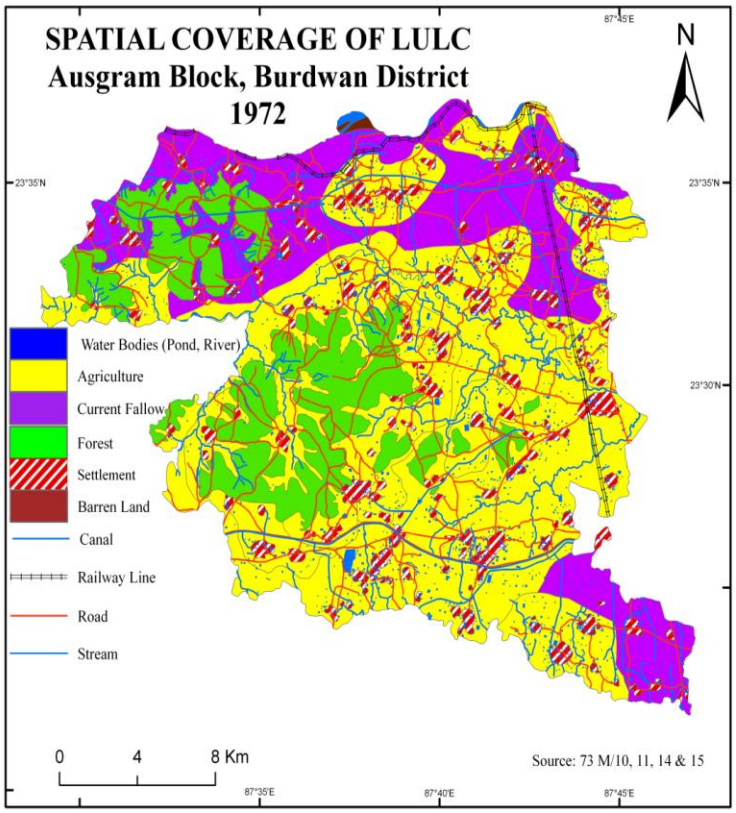


**Figure 2: Spatial Coverage of Land Use Land Cover 1972**

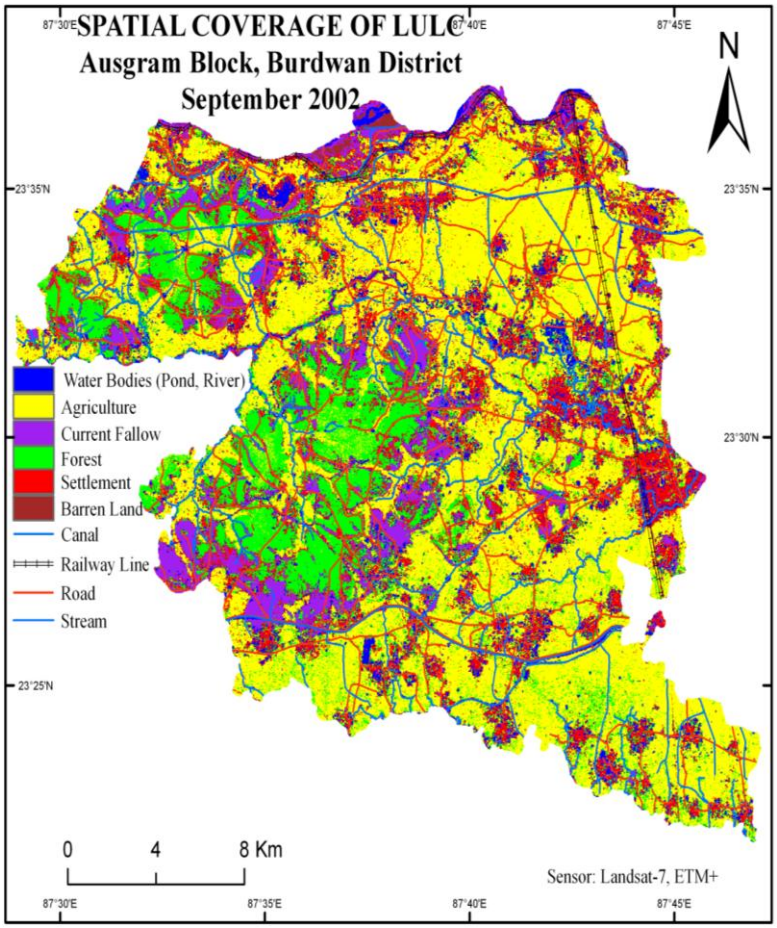


**Figure 3: Spatial Coverage of Land Use Land Cover September - 2002**

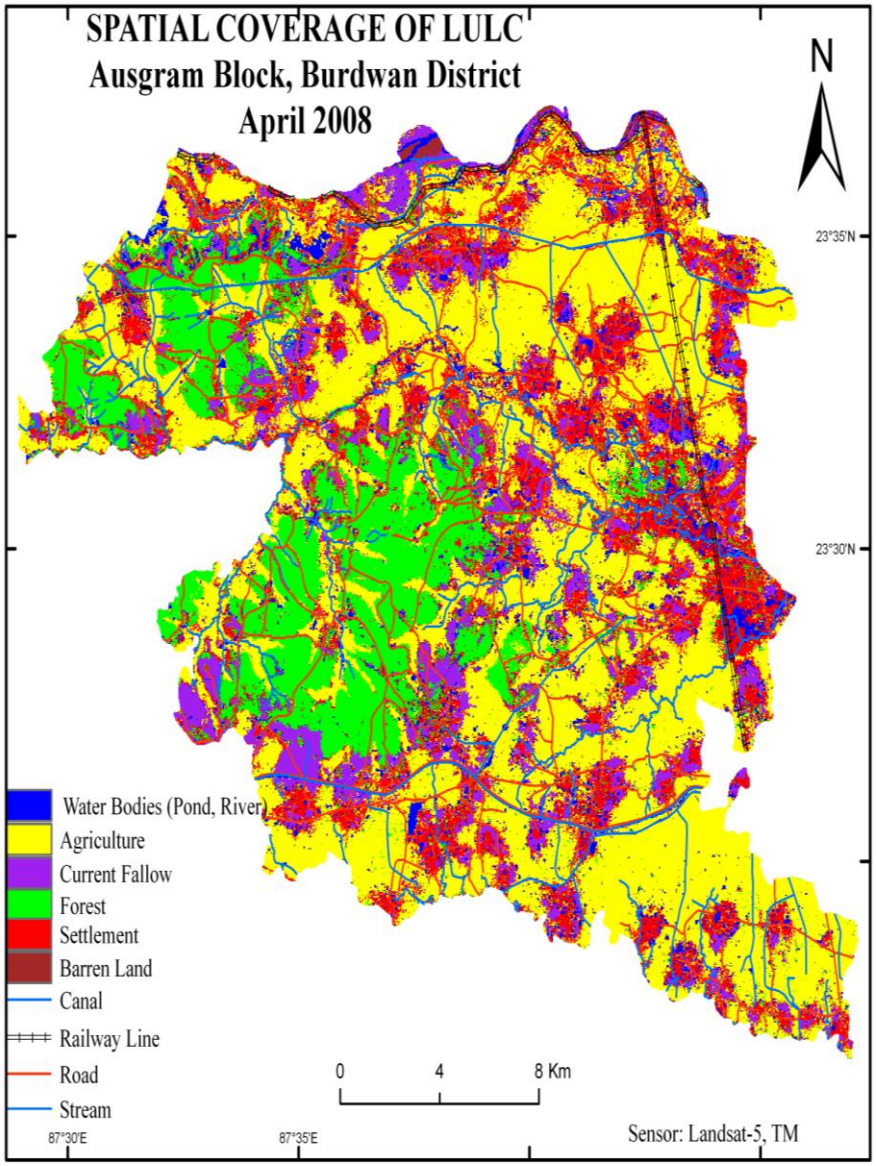


**Figure 4: Spatial Coverage of Land Use Land Cover April - 2008**

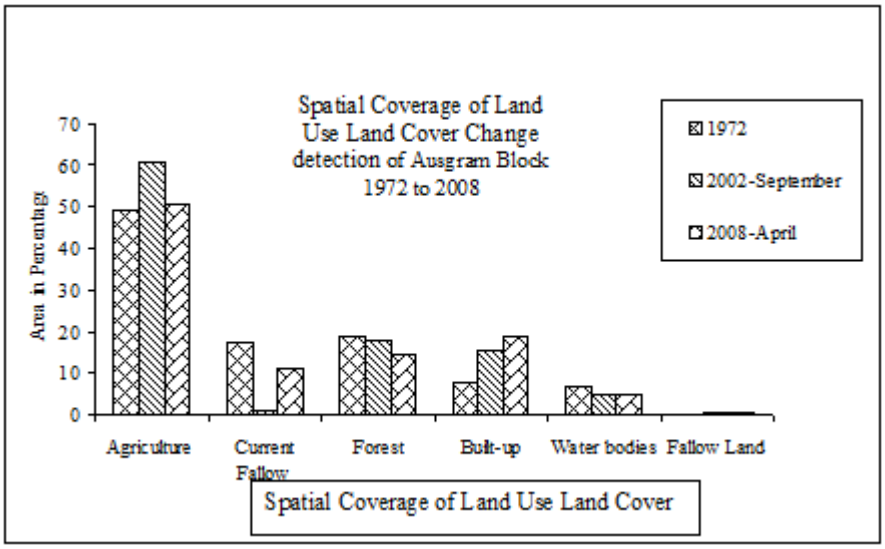


**Figure 5: Spatial Coverage of Land Use Land Cover Change Detection**

**Table 1: Data Sets Used for the Present Study**

| Data | Date of Observation / Survey and No. | Spatial Resolution / Scale |
|---|---|---|
| Topographical Maps | 1972, 73 M/10, 11, 14 & 15 | 1: 50000 |
| Land Sat-7(ETM+) | September-2002 | 30 m |
| Land Sat -5(TM) | April- 2008 | 30 m |

**Table 2: Spatial Coverage of Land Use Land Cover of Ausgram Block**

| | | 1972 | | 2002-September | | 2008-April | |
|---|---|---|---|---|---|---|---|
| **Sl. No** | **Land Use Land Cover** | **Area (Hec.)** | **Area (%)** | **Area (Hec.)** | **Area (%)** | **Area (Hec.)** | **Area (%)** |
| 1 | Agriculture | 24169.52 | 49.03 | 29908.00 | 60.67 | 24940.00 | 50.59 |
| 2 | Current Fallow | 8530.00 | 17.30 | 497.00 | 1.01 | 5495.00 | 11.15 |
| 3 | Forest | 9400.00 | 19.07 | 8756.00 | 17.76 | 7071.00 | 14.34 |
| 4 | Built-up | 3807.00 | 7.72 | 7532.00 | 15.28 | 9200.00 | 18.66 |
| 5 | Water bodies | 3328.00 | 6.75 | 2472.30 | 5.01 | 2494.71 | 5.06 |
| 6 | Barren land | 65.48 | 0.13 | 134.70 | 0.27 | 99.29 | 0.20 |
| | **Total** | **49300.00** | **100.00** | **49300.00** | **100.00** | **49300.00** | **100.00** |

**Source:** Author's Calculation

**Table 3: Spatial Coverage of Surface Water Bodies of Ausgram Block**

| Sl.No | Water Bodies Name | Length(K.M.) |
|---|---|---|
| 1 | Ajay River | 37.95 |
| 2 | Kunur Nadi | 166.3 |
| 3 | Kanakhori Nadi | 3.142 |
| 4 | Kandor Nadi | 13.09 |
| 5 | Kandar Nadi | 23.77 |
| 6 | Khari Nadi | 19.42 |
| 7 | Durgapur Branch Canal | 48.32 |
| 8 | Damodar Branch Canal | 21.383 |
| 9 | Panagarh Branch Canal | 38.30 |
| 10 | Distributary No. 7ABC | 4.771 |
| 11 | Distributary No. 7BC | 3.005 |
| 12 | Distributary No. 8BC | 2.064 |

**Source:** Author's Calculation